

# PATENT SPECIFICATION

DRAWINGS ATTACHED

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## COMPLETE SPECIFICATION

### Improvements in or relating to Foamed Polymers

We, FORMICA INTERNATIONAL LIMITED, a British company, of De La Rue House, 84/86, Regent Street, London, W.1, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to foamed polymers, especially foamed polystyrene and substituted polystyrenes.

Foamed polymers are made by incorporating in a mass of the polymer a substance, on suitable treatment, greatly expands in volume. Usually the substance is a liquid or solid (or a mixture of liquids and/or solids) which on being heated gives rise to a relatively large volume of gas or vapour. Such substances are well known.

The usual method of heating the polymer composition to cause it to expand or foam is by applying external heat to granules thereof, preferably by means of steam. However most polymers are poor conductors of heat, and their conductivity is reduced still further by the formation of cavities on foaming, so that such heating methods are relatively slow and inefficient.

After they have been expanded or foamed it is a common practice to form the granules into a continuous structure, for example sheet material, by sintering in a suitable mold. External heating, and especially steaming, is employed for this operation also, and is open to the same objections.

According to the present invention, foamed polymer granules are made, or foamed polymer granules are sintered, with the aid of dielectric heating, that is to say the generation of heat inside the polymer by applying to it a high frequency alternating electric field.

While the process of the invention is applicable generally to the production and sintering of foamed polymer granules, including for example foamed polyvinyl chloride granules, by processes involving heating, it is particularly applicable to styrene polymers, and will be described in more detail by reference to such polymers.

If the power factor of the polymer is very low, as for example is the case with polystyrene itself, it is preferable (and this is a further feature of the invention) to incorporate in the polymer a substantial proportion of a substance of considerably higher power factor so as to increase the power factor of the composition, and thus the amount of heat produced under given conditions. The added substance should of course be compatible with the polymer and should not exert any deleterious effect on it; indeed it may be so chosen that the properties of the resulting composition are in some respects more valuable than those of the polymers alone. Thus a plasticiser having a high power factor at high frequencies may often be employed with advantage.

The proportion of additive employed is preferably as high as is consistent with the retention by the polymer of the properties desired. For example it may be between about 1% and 50% or even more. Other things being equal, the higher the power factor of the additive the shorter is the heating time required with a given concentration, and the lower concentration needed to achieve a given heating time.

It has however been further found that the effectiveness of such an additive does not, as would have been expected, depend only on its power factor and the proportion in which it is contained in the polymer, but also, especially at lower concentrations, on a factor which

is believed to be related to the friction or physical interaction between the molecules of the additive and those of the polymer. The relative importance of this factor diminishes as the concentration of the additive in the polymer increases.

Examples of suitable additives for use with polystyrene are aromatic sulphonamides and halogenated hydrocarbons especially liquid or solid chlorinated hydrocarbons. Of these the aromatic sulphonamides, such for example as the toluene sulphonamides, particularly a mixture of *o*- and *p*-toluene sulphonamides sold as "Santizizer 9", are exceptionally useful, apparently as a result of having a high value for the "friction factor" referred to above ("Santizizer" is a Registered Trade Mark). The halogenated hydrocarbons are less effective, especially in relatively low concentrations, e.g. 25% or below, but their efficiency greater extent than can be accounted for solely by the greater amount which is present. Examples of such additives which are readily available commercially are tetrachlorobiphenyl and mixtures of dichloropentanes, e.g. the "dichloropentanes No. 40" sold by Pennsaks Chemical Corporation of the United States of America.

Polymers with more strongly polar structural units such for example as chlorinated or brominated polystyrene with a halogen content of 20—25% or more will normally reach the desired foaming or sintering temperature sufficiently rapidly without the presence of additives. However, such additives especially of the highly effective aromatic sulphonamide type, can be added if desired, and indeed may be very advisable with polymers of relatively low content of polar groups, such as chlorinated or brominated polystyrenes of halogen content below 20—25%.

Since the time required to attain the necessary temperature, will be less, the higher the frequency and the greater the field strength, it is usually desirable that both these parameters should be given their maximum practical values. Practical considerations set upper limits of about  $10^7$  cycles/second for the frequency and  $10^5$  volts/metre for the field strength, and it is advisable in general to employ values near to these limits, especially frequencies of  $10^6$ — $10^7$  cycles/second and field strengths of  $10^3$ — $10^5$ , and better  $10^4$ — $10^5$  volts/metre. With chlorinated polystyrene of chlorine content 25% or more and compositions comprising polystyrene and a fairly high proportion of an efficient additive, a temperature of 120° C.—130° C. can usually be reached in 1—2 minutes.

Similar conditions may be used for sintering expanded granules. For example they may be formed into a sheet held between two flat electrodes spaced apart by a distance corresponding to the thickness of the product de-

sired, and used to produce an alternating field of a frequency and field strength indicated above.

In one preferred embodiment of the invention the polymer or polymer composition to be foamed is preferably subjected, in the form of granules, to the high frequency field while passing continuously between plate-formed electrodes. A suitable form of apparatus, which is a further feature of the invention, comprises such electrodes, preferably in the form of rectangles or near rectangles, spaced apart one above the other, and a conveyor belt or like transporting means adapted to travel between them close to the upper surface of the lower electrode so as to provide as much space as possible for the polymer carried thereon, not only at the input end but also at the output end where the polymer has become expanded or foamed. Usually it is preferable to employ electrodes which are long in relation to their width, and to arrange the conveyor to travel in the longitudinal direction of the electrodes so as to give the maximum heating time for a given rate of travel. The electrodes may be parallel, but when the apparatus is to be used for expanding the granules they are preferably closer together at the input end than at the output end, so as to provide room for expansion while keeping the field strength at the input end at a maximum. While the dimensions of the apparatus will naturally depend on many factors, it may be mentioned that a layer of polystyrene or chlorinated polystyrene granules about 1/8 inch thick will usually become about 4 inch thick when expansion is complete.

It is of course not necessary that dielectric heating should be employed for both the expanding and the sintering steps in a process including both, though this will usually be preferred. For example one or other of the steps may be effected by steaming in the known way.

A form of apparatus that may be used in carrying out the invention is illustrated in the drawing accompanying the provisional specification in which the figure is a diagrammatic side view in section of an apparatus for expanding the polymer granules.

Referring now to the drawing, the apparatus comprises a lower electrode 1 and upper electrode 2, and running between them, and very close to the lower of them, a continuous conveyor belt 3 driven by end driving rolls 4, 5 and supported immediately before it reaches the electrodes by a guide roll 6. Between the drive roll 4 and guide roll 6 and above the conveyor belt a feed hopper 7 is provided whereby a layer 8 of polymer granules can be deposited on the conveyor belt at a constant thickness corresponding to the minimum distance between the conveyor belt and the upper electrode as described below. A collecting hopper 9 is provided to

receive expanded polymer 10 falling from the conveyor belt as it passes over driving roll 5.

The electrodes are rectangular, being for example 4—5 times as long as they are wide. At the end nearer to the feed hopper they are spaced quite closely, e.g. less than an inch and preferably less than half an inch apart; along the direction of travel of the conveyor belt they diverge at a uniform rate until at the other end they are some 30—40 times as far apart.

In operation the desired alternating potential is applied to the electrodes 1, 2, the conveyor belt 3 is set in motion from left to right as shown in the drawing, and the polymer granules to be expanded are fed from the feed hopper 7 onto the belt at a rate such that they form on the belt a layer 8 which is preferably only very slightly less than the distance between the belt and the edge of the upper electrode at its lowest point. As they pass between the electrodes the granules are heated and expanded. The rate of travel of the belt is so correlated with the dimensions of the apparatus and with the other variables that on leaving the space between the electrodes the granules are expanded to the desired extent, usually to the maximum practicable extent. The expanded granules 10 are collected in the collecting hopper 9.

A similar device can be used for continuously sintering a layer of expanded granules, except that the electrodes are parallel, being spaced apart for example by 1 foot or more in accordance with the thickness of the layer to be sintered.

The invention is illustrated by the following examples.

#### EXAMPLE I.

An apparatus similar to that described above is employed, in which the electrodes are 9 feet long and 2 feet broad and spaced 0.2 inches apart at the end where the granules are fed in and 4.0 inches apart at the end where the expanded granules emerge, and the conveyor belt travels at 6 feet/minute, giving a heating time of  $1\frac{1}{2}$  minutes. The polymer is polystyrene containing 10% of its weight of a mixture of *o*- and *p*-toluene-sulphonamides uniformly distributed, and is in the form of conventional expandable granules (comprising about 8% of petroleum ether, reckoned on the weight of the polystyrene) of bulk density 0.75 g./cc. The polymer is deposited on the belt at a loading of  $\frac{1}{2}$  lb./sq. foot. The potential difference between the electrodes is 1000 volts, and the frequency  $12 \times 10^6$  cycles per second. (Generally, frequencies between  $10 \times 10^6$  and  $15 \times 10^6$  give similar results). On leaving the device the polymer granules are fully expanded, and have a bulk density of about 2.25 g./100 cc.

#### EXAMPLE II.

The process of Example I is repeated using expandable granules of polystyrene containing 16% of its weight of tetrachlorobiphenyl. A foamed product is obtained of bulk density similar to that of the product of Example I.

#### EXAMPLE III.

The process of Example I is repeated, using expandable granules of a chlorinated polystyrene of chloride content 25%. Again a similar foamed product results.

#### EXAMPLE IV.

Expanded polymers obtained in accordance with each of Examples I—III are formed into sheets 24 inches thick held between flat electrodes 24 inches apart to which is applied a potential difference of  $5 \times 10^4$  volts at a frequency of  $12 \times 10^6$  cycles per second. After 2 minutes the granules have become well sintered and converted into a continuous sheet. Similar results are obtained using generally potential differences between  $10^4$  and  $10^5$  volts and frequencies between  $10 \times 10^5$  and  $15 \times 10^6$ .

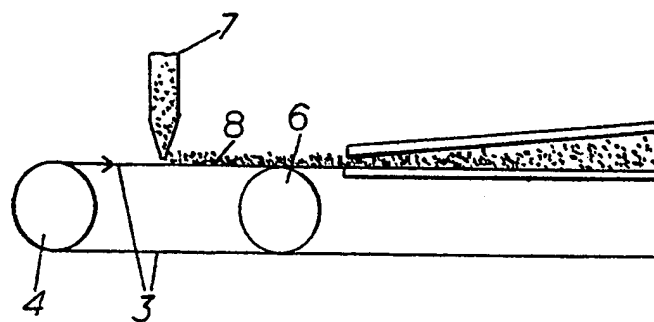
Specification No. 873,443 claims a method of treating expandable polymeric particles having a low power loss factor, which method comprises the steps of covering the particles with material having a high power loss factor said material comprising water in combination with a wetting or coating agent, the weight ratio of particles to material being between 25:1 and 1:1, exposing the covered particles to a high frequency electric field until softening and expansion of the particles occur, whereby an integral polymeric cellular structure having low density and uniform small voids is formed, and removing the structure from the high frequency field before charring occurs. This method is not claimed here.

Subject to the foregoing disclaimer, what we claim is:—

1. Process for the production or sintering of expanded polymer granules by heating polymer granules containing a foaming agent or expanded polymer granules respectively, wherein the heat required is generated within the granules by applying to them a high frequency alternating electric field.
2. Process according to Claim 1, wherein the polymer granules contain a compatible substance of higher power factor.
3. Process according to Claim 2, wherein the substance of higher power factor is a plasticiser for the polymer.
4. Process according to Claim 2 or 3, wherein the polymer is polystyrene or a chlorinated or brominated polystyrene of halogen content below 25% by weight.
5. Process according to Claim 4, wherein the polymer granules contain an aromatic sulphonamide, or a liquid or solid chlorinated hydrocarbon.

6. Process according to Claim 5, wherein the granules contain a toluene sulphonamide.
7. Process according to any one of Claims 2—6, wherein the granules contain 1—50% by weight of the substance of higher power factor.
8. Process according to any one of the preceding claims, wherein the strength of the field produced by the alternating potential is  $10^3$ — $10^5$  volts/metre and the frequency is  $10^6$ — $10^7$  cycles/second.
9. Process for the production or sintering of expanded polymer granules substantially as described by reference to the drawing accompanying the provisional specification or in the foregoing examples.
10. Expanded polymer granules, and sintered masses of expanded polymer granules, obtained by a process claimed in any one of Claims 1—9.
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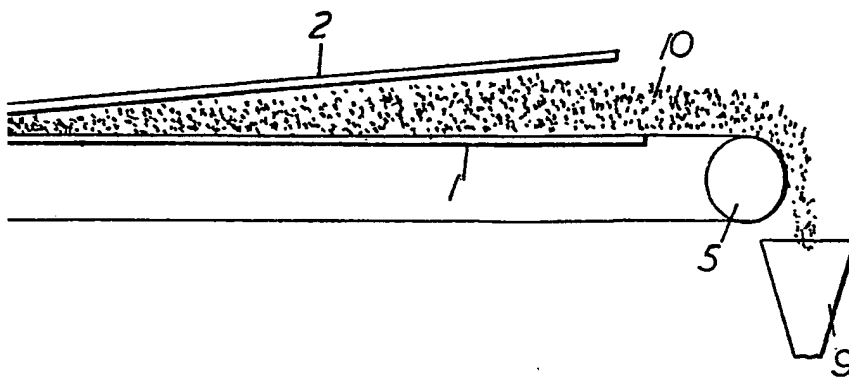


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PROVISIONAL SPECIFICATION

1 SHEET

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the Original on a reduced scale.*



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